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(54) **METAL SEGMENTS AS LANDING PADS AND LOCAL INTERCONNECTS IN AN IC DEVICE**

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H01L 21/82 (2006.01)
H01L 27/11 (2006.01)
H01L 27/02 (2006.01)
H01L 23/522 (2006.01)
H01L 23/528 (2006.01)

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CPC **H01L 27/1104** (2013.01); **H01L 23/5226** (2013.01); **H01L 23/5286** (2013.01); **H01L 27/0207** (2013.01)

(58) **Field of Classification Search**

CPC H01L 29/66795; H01L 29/785; H01L 29/4238; H01L 29/0696; H01L 21/823481; H01L 21/76232; H01L 21/82378; H01L 21/84

USPC 257/401; 438/294
See application file for complete search history.

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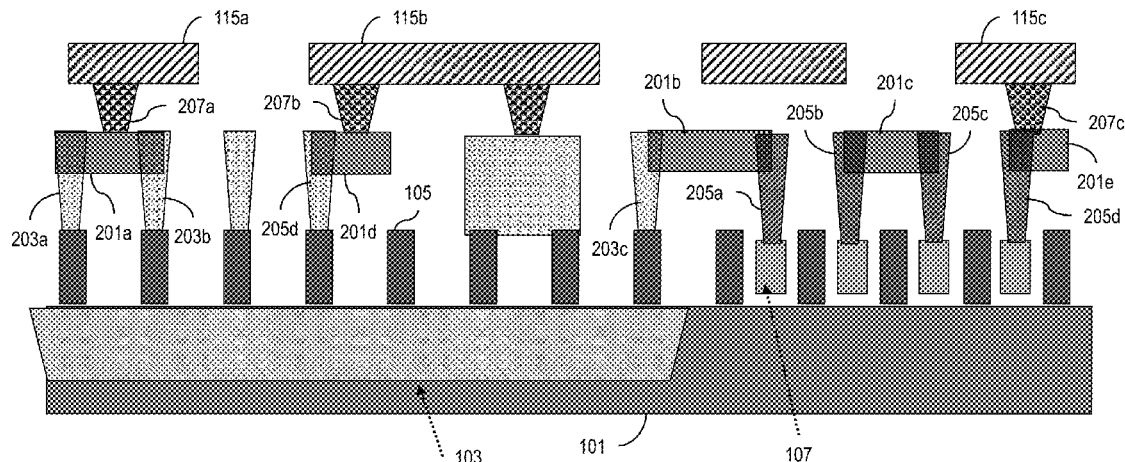
Primary Examiner — Monica D Harrison

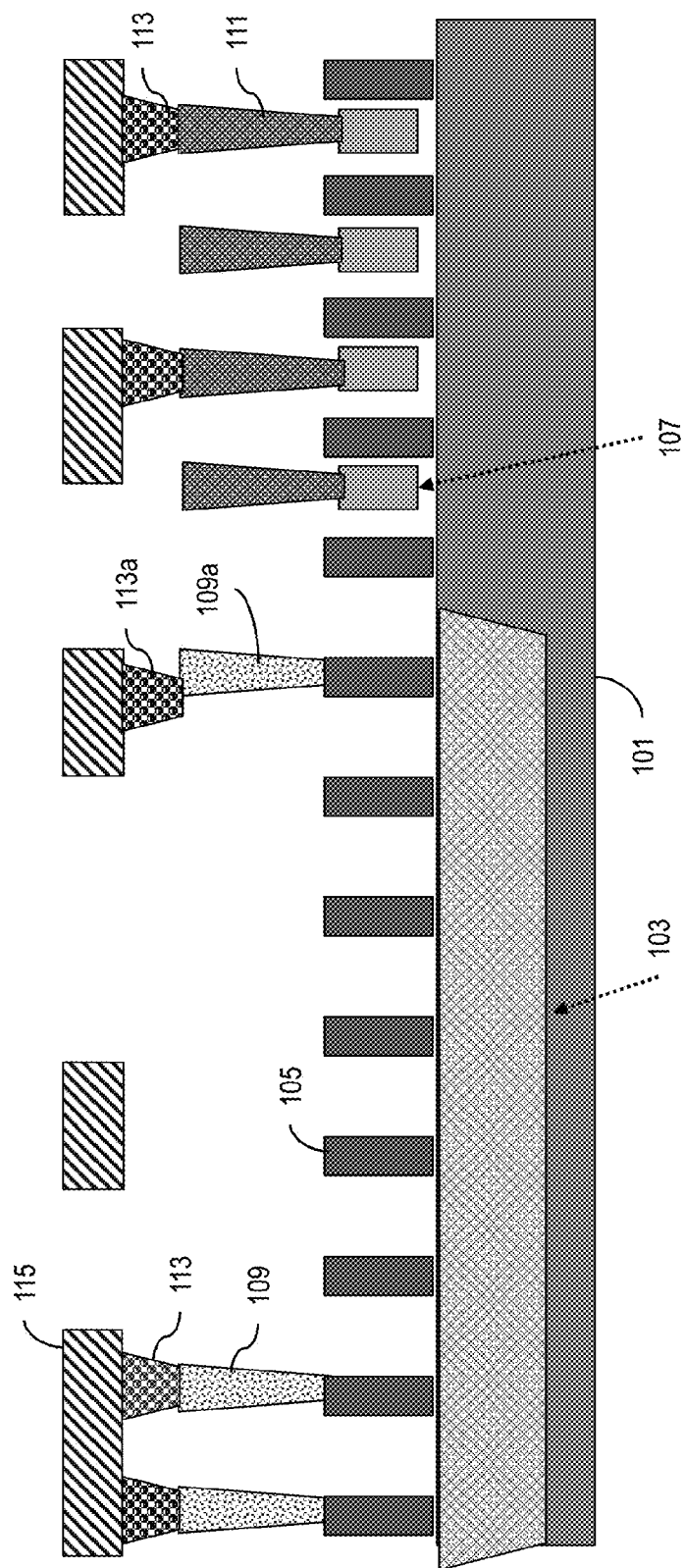
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(57) **ABSTRACT**

Methods for utilizing metal segments of an additional metal layer as landing pads for vias and also as local interconnects between contacts in an IC device and resulting devices are disclosed. Embodiments include forming source/drain and gate contacts connected to transistors on a substrate in an integrated circuit device, each contact having an upper surface with a first area; forming metal segments in a plane at the upper surface of the contacts, each metal segment being in contact with one or more of the contacts and having a second area greater than the first area; and forming one or more vias between one or more of the metal segments and one or more first segments of a first metal layer.

20 Claims, 6 Drawing Sheets





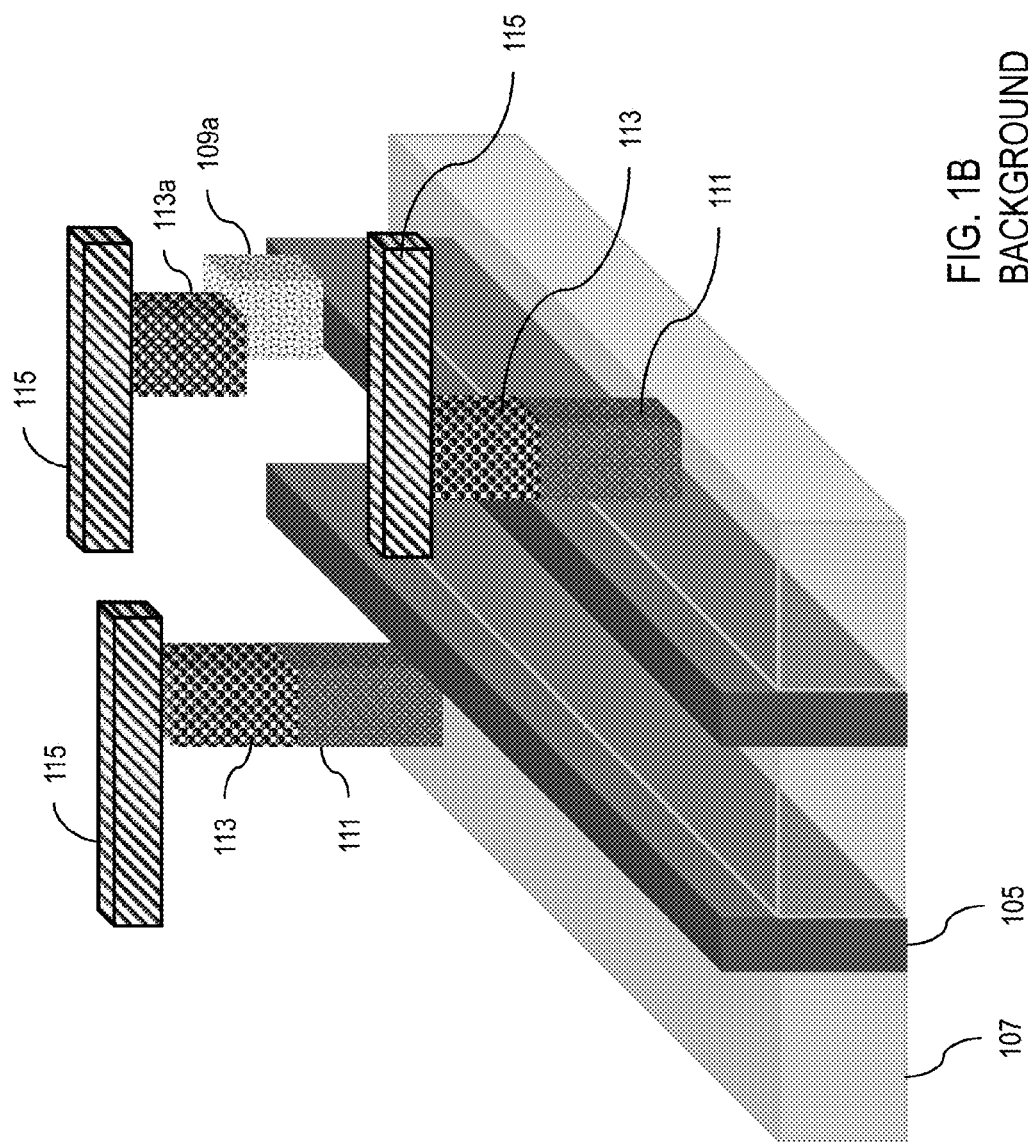


FIG. 1B
BACKGROUND

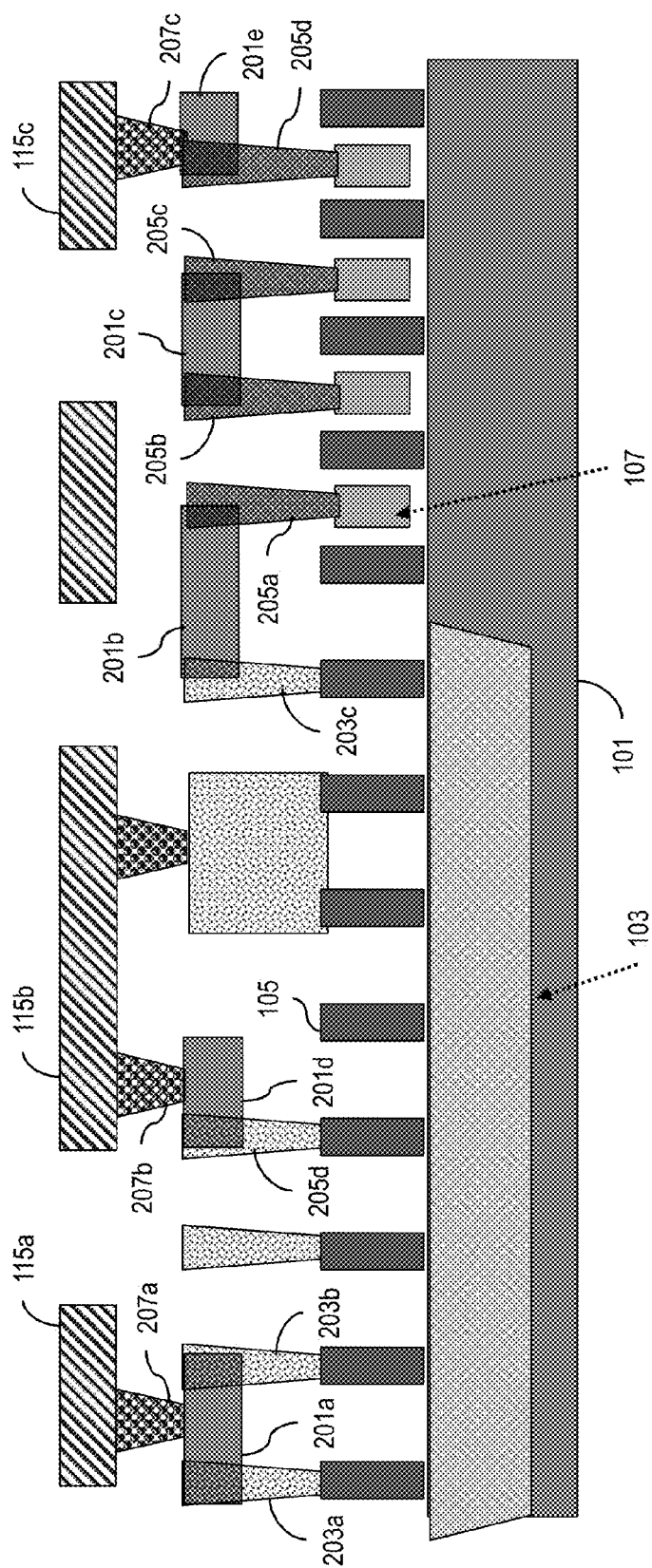
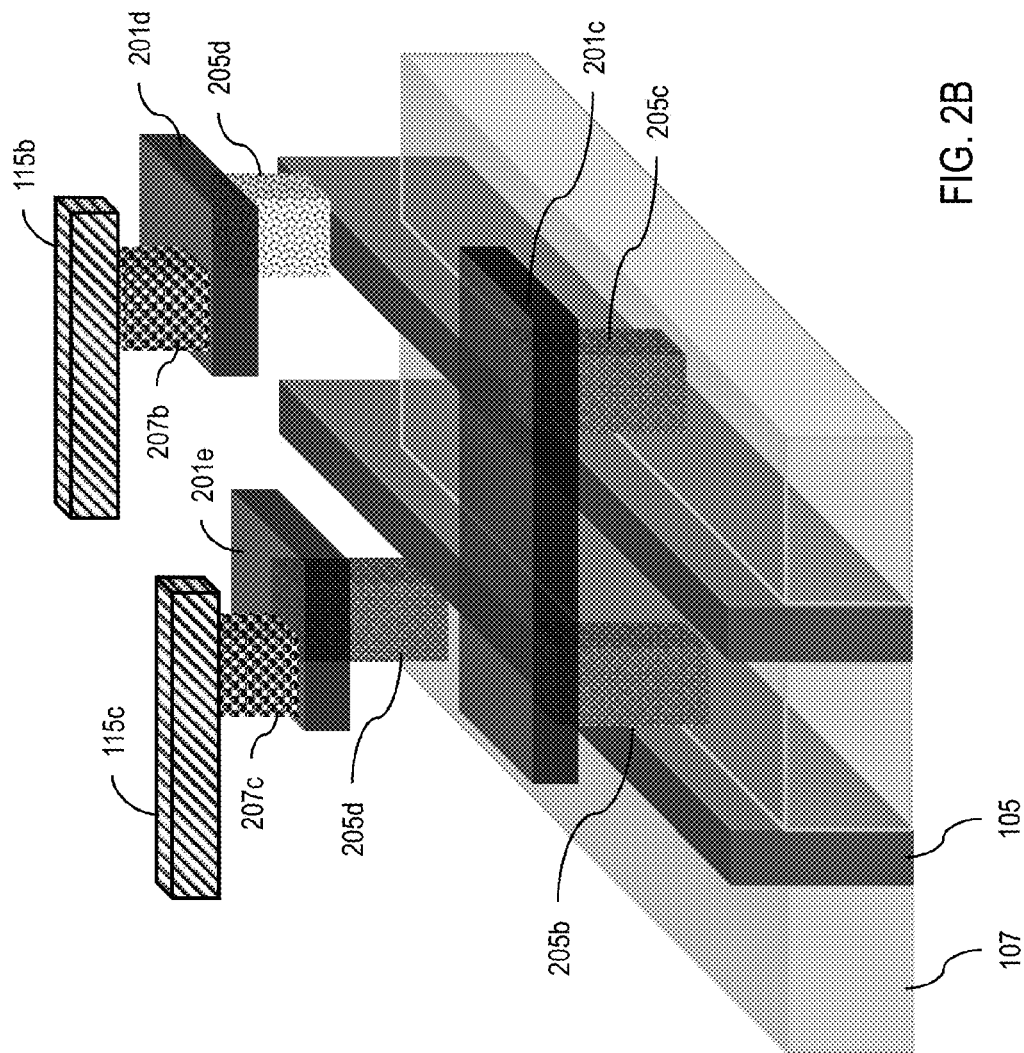


FIG. 2A



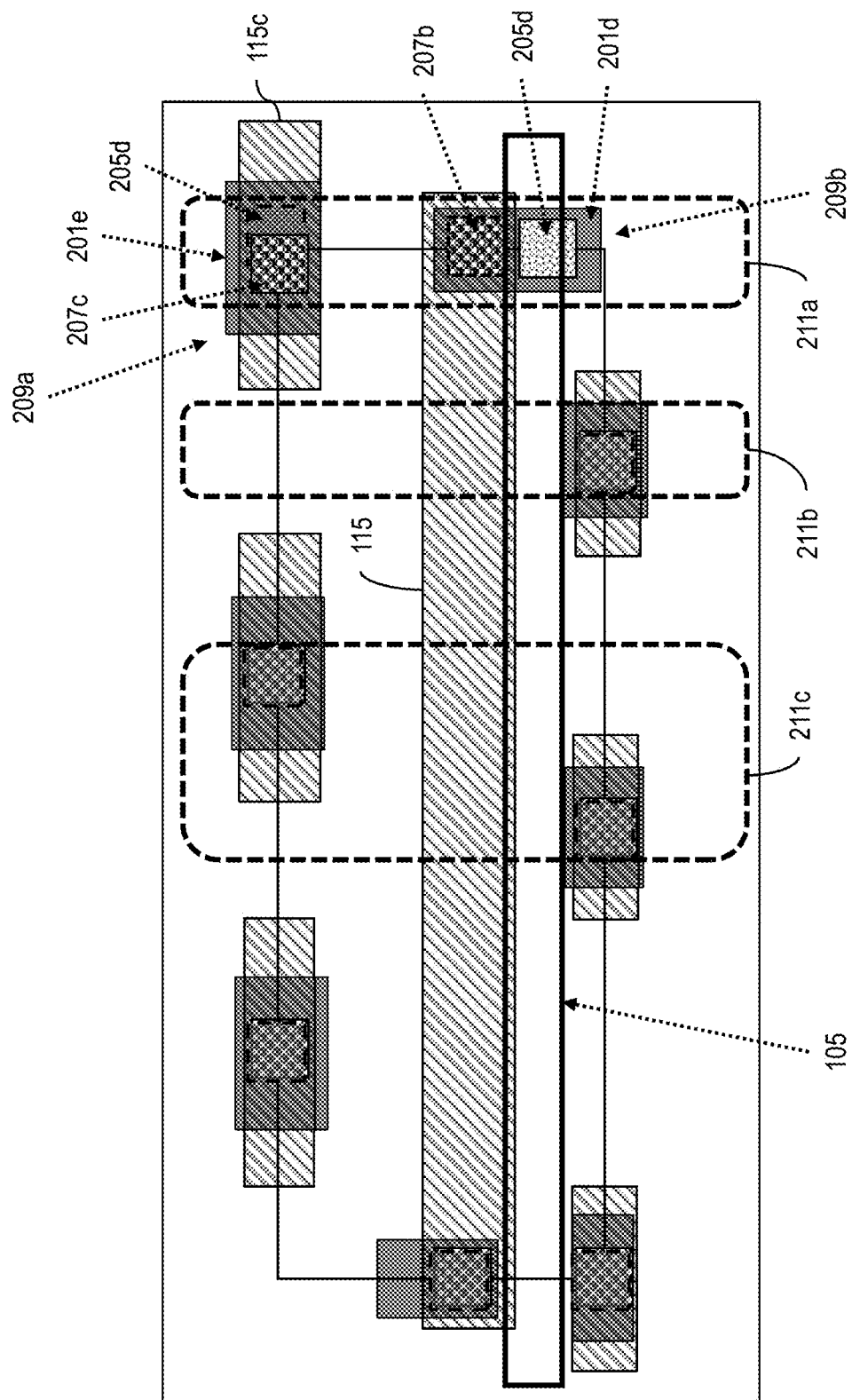


FIG. 2C

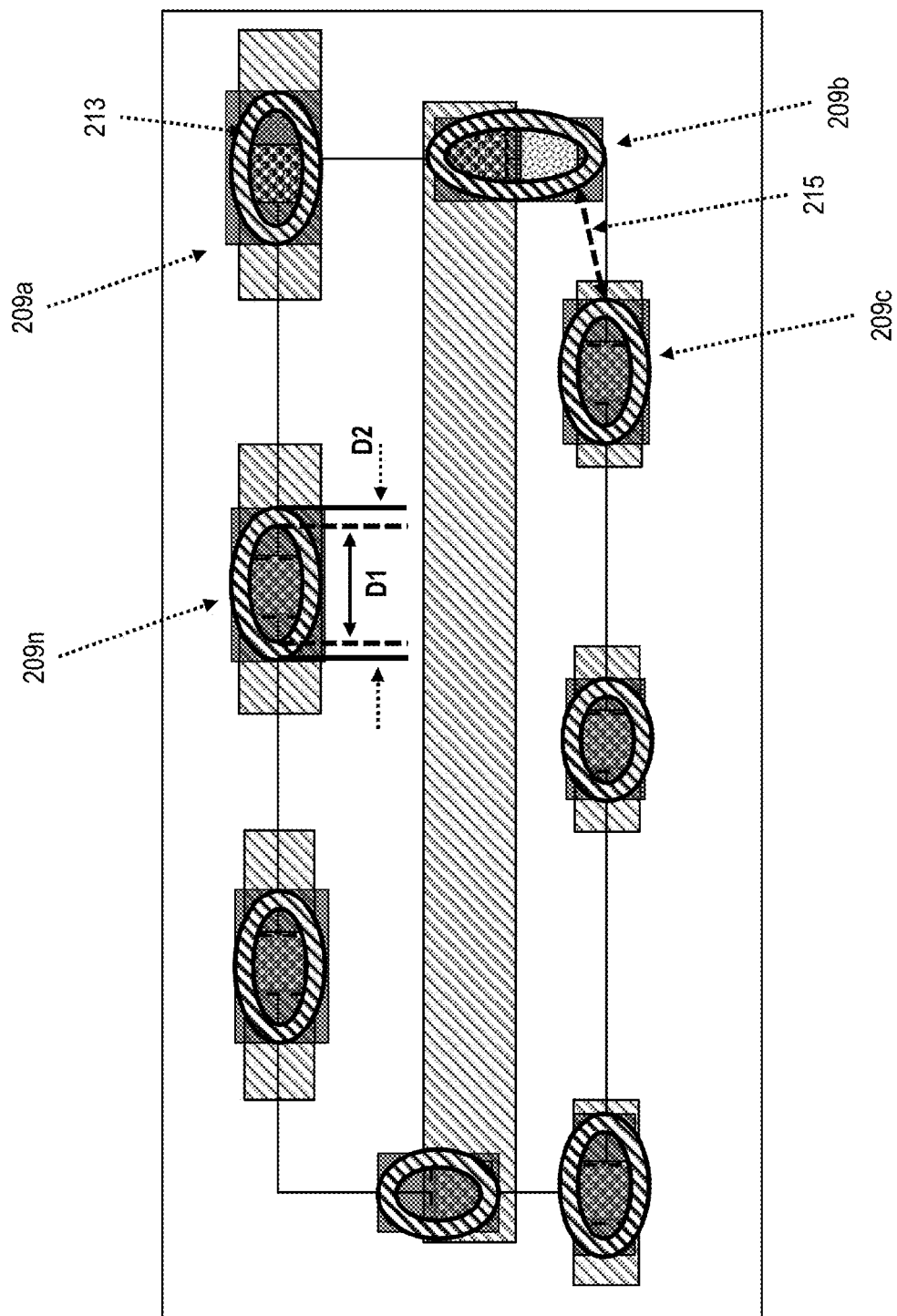


FIG. 2D

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METAL SEGMENTS AS LANDING PADS AND LOCAL INTERCONNECTS IN AN IC DEVICE

TECHNICAL FIELD

The present disclosure relates generally to designing and fabricating integrated circuit (IC) devices. The present disclosure is applicable to connections between vias and contacts and to local interconnects between contacts in an IC device, particularly for 7 nanometer (nm) technology nodes and beyond.

BACKGROUND

Generally, an IC device may include various square contacts that are connected to one or more transistors. Additionally, the IC device may include a plurality of metal layers that may be utilized to connect the contacts to various signal sources or targets. In some instances, vias may be utilized to connect an upper metal layer to one or more of the contacts. For example, a via may be utilized to connect a segment of a metal-one (M1) layer to a gate contact on a transistor. However, in some instances, a via may not be substantially aligned with the small square surface area of a target contact, which may cause unreliable connection (e.g., a small contact area) between the via and the target contact. Hence, an unreliable connection between the target contact and the segment of the upper M1 layer results, which may cause the device to be unable to function properly or pass certain IC manufacturing quality/reliability tests, which in turn could negatively impact the manufacturing yield of the IC devices. Additionally, layout of certain metal layers in the IC device may impact advancements in node scaling technologies of the IC devices.

FIGS. 1A and 1B are cross-sectional and three-dimensional diagrams, respectively, of an example IC device. Adverting to FIG. 1A, a cross-section of a conventional static random access memory (SRAM) device is illustrated, which includes a silicon substrate **101** and a shallow trench insulating layer **103**. Additionally, on the upper surface of the silicon substrate **101** are a plurality of gate electrodes (PC) **105** and a plurality of trench silicides (TS) **107**, wherein gate contacts (CB) **109** connect to upper surfaces of PCs **105**, and source/drain contacts (CA) **111** connect to upper surfaces of TS's **107**. Further, vias **113** connect one or more segments of an M1 layer **115** to upper surfaces of CB contacts **109** and/or CA contacts **111**. However, the bottom surface of a via, for example via **113a**, may not be completely aligned with an upper surface of a CB contact, e.g. contact **109a** (or other CA or CB contacts), which may result in an insufficient contact area for reliable functionality and a proper transfer of power or signals between the two elements.

FIG. 1B illustrates a 3D diagram of the IC device in FIG. 1A where the via **113a** is horizontally misaligned with the CB contact **109a**. The misalignment between via **113a** and CB contact **109a** is merely exemplary; many more instances of misalignment may exist in an IC device between vias and both CB contacts and CA contacts. As noted, among considerations in designing and fabricating IC devices are steps for providing sufficient and efficient contact layout designs for providing reliable and economical manufacturing yields of the IC devices.

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A need therefore exists for a methodology enabling improved connections between contacts and vias in an IC device and the resulting device.

SUMMARY

An aspect of the present disclosure is an IC device that utilizes metal segments of an additional metal layer as landing pads for vias and also as local interconnects between contacts.

Another aspect of the present disclosure is a method for utilizing metal segments of an additional metal layer as landing pads for vias and also as local interconnects between contacts in an IC device.

Additional aspects and other features of the present disclosure will be set forth in the description which follows and in part will be apparent to those having ordinary skill in the art upon examination of the following or may be learned from the practice of the present disclosure. The advantages of the present disclosure may be realized and obtained as particularly pointed out in the appended claims.

According to the present disclosure some technical effects may be achieved in part by a method including forming source/drain and gate contacts connected to transistors on a substrate in an integrated circuit device, each contact having an upper surface with a first area; forming metal segments in a plane at the upper surface of the contacts, each metal segment being in contact with one or more of the contacts and having a second area greater than the first area; and forming one or more vias between one or more of the metal segments and one or more first segments of a first metal layer.

Another aspect includes forming one or more local connections between one or more of the metal segments and one or more of the source/drain and gate contacts. Some aspects include forming second segments of a second metal layer perpendicular to the gate contact and the one or more first segments of the first metal layer.

Another aspect includes forming vias connecting one or more of the metal segments or one or more of the first segments of the first metal layer to the second metal layer. In one aspect, the method includes forming first and second interlayer dielectric (ILD) layers; forming the vias through the ILD layers; and forming the metal segments and the first metal layer in the first ILD layer, and the second metal layer in the second ILD layer.

Further aspects include connecting one or more of the second segments of the second metal layer to a power layer, a ground layer, and a bit line. Additional aspects include forming the metal segments based on process variation (PV) bands including an inner edge and an outer edge. In one aspect, the PV bands of adjacent metal segments are separated by a threshold distance.

Another aspect of the present disclosure includes a device including: source/drain and gate contacts connected to transistors on a substrate in an integrated circuit device, each contact having an upper surface with a first area; metal segments in a plane at the upper surface of the contacts, each metal segment being in contact with one or more of the contacts and having a second area greater than the first area; and one or more vias between one or more of the metal segments and one or more first segments of a first metal layer.

In some aspects of the device, one or more of the metal segments form one or more local interconnects with one or more of the source/drain and gate contacts. Other aspects of the device include second segments of a second metal layer

perpendicular to the gate contact and the one or more first segments of the first metal layer. One aspect of the device includes vias connecting one or more of the metal segments or one or more of the first segments of the first metal layer to the second metal layer.

Further aspects of the device include first and second ILD layers, wherein the vias are through the ILD layers, and wherein the metal segments and the first metal layer are in the first ILD layer, and the second metal layer is in the second ILD layer. Some aspects of the device include one or more of the second segments of the second segments of the second metal layer that are connected to a power layer, a ground layer, and a bit line. One aspect of the device includes the metal segments that are based on PV bands that include an inner edge and an outer edge. In additional aspects of the device, the PV bands of adjacent metal segments are separated by a threshold distance.

Additional aspects and technical effects of the present disclosure will become readily apparent to those skilled in the art from the following detailed description wherein embodiments of the present disclosure are described simply by way of illustration of the best mode contemplated to carry out the present disclosure. As will be realized, the present disclosure is capable of other and different embodiments, and its several details are capable of modifications in various obvious respects, all without departing from the present disclosure. Accordingly, the drawings and description are to be regarded as illustrative in nature, and not as restrictive.

BRIEF DESCRIPTION OF THE DRAWINGS

The present disclosure is illustrated by way of example, and not by way of limitation, in the figures of the accompanying drawing and in which like reference numerals refer to similar elements and in which:

FIGS. 1A and 1B are cross-sectional and three-dimensional (3D) diagrams, respectively, of an example IC device;

FIGS. 2A, 2B, and 2C are cross-sectional, three-dimensional (3D), and layout diagrams, respectively, of an IC device utilizing metal segments of an additional metal layer, in accordance with an exemplary embodiment; and

FIG. 2D illustrates a layout diagram including contact points and associated process variation bands in an IC device, in accordance with an exemplary embodiment.

DETAILED DESCRIPTION

In the following description, for the purposes of explanation, numerous specific details are set forth in order to provide a thorough understanding of exemplary embodiments. It should be apparent, however, that exemplary embodiments may be practiced without these specific details or with an equivalent arrangement. In other instances, well-known structures and devices are shown in block diagram form in order to avoid unnecessarily obscuring exemplary embodiments. In addition, unless otherwise indicated, all numbers expressing quantities, ratios, and numerical properties of ingredients, reaction conditions, and so forth used in the specification and claims are to be understood as being modified in all instances by the term “about.”

The present disclosure addresses and solves the problem of misalignment between vias and contact surfaces in an IC device. The present disclosure addresses and solves such problems, for instance, by, inter alia, utilizing metal segments of an additional metal layer as landing pads for vias and also as local interconnects between contacts in an IC device.

FIG. 2A illustrates a cross sectional view of an IC device where a plurality of metal segments, for example **201a** through **201e**, of an additional metal layer, e.g., a metal-zero (M0) layer, which may be implemented in middle-of-line (MOL) IC fabrication processes. Although only five segments are illustrated, the number of segments is merely exemplary. The plurality of metal segments **201a** through **201e** of the M0 layer may be utilized to provide local interconnections between two or more CB contacts **203a** through **203d** and/or two or more CA contacts **205a** through **205d** in the IC device. For example, M0 metal segment **201a** interconnects CB contacts **203a** and **203b**, M0 metal segment **201b** interconnects CB contact **203c** and CA contact **205a**, and M0 metal segment **201c** interconnects CA contacts **205b** and **205c**. Additionally, the M0 metal segments **201a** through **201e** may provide landing pads for vias **207a** through **207c**. In addition, an interconnecting M0 metal segment **201** may also provide a landing pad for a via **207** that may be connected to another metal layer. For example, in addition to providing a local interconnection, the M0 metal segment **201a** provides a landing pad for via **207a**, which is connected to a segment **115a** of the M1 layer **115**. In another example, M0 metal segment **201d** is connected to CB contact **205d** and provides a landing pad for via **207b** (e.g., the via and the CB contact are not horizontally aligned), which is connected to a metal segment **115b** of the M1 layer. In another example, M0 metal segment **201e** is connected to CA contact **205d** and provides a landing pad for via **207c**, which is connected to segment **115c** of the M1 layer, as via **207c** and CA contact **205d** are only partially aligned. Like the M0 segments, the number of CA contacts, CB contacts, vias, and M1 segments shown in FIG. 2A is merely exemplary.

FIG. 2B illustrates a 3D view of some of the connections discussed in FIG. 2A where, for example, the M0 metal segment **201c** interconnects CA contacts **205b** and **205c**, the M0 metal segment **201d** is connected to the CB contact **205d** and provides a landing pad for the via **207b**, and the M0 metal segment **201e** is connected to CA contact **205d** and provides a landing pad for the via **207c**.

FIG. 2C illustrates a top view of an example layout diagram of the IC device in FIG. 2A, wherein the layout may include a plurality of contact points **209a** and **209b**. The layout diagram includes a contact point **209a** where a metal segment **211a** of the M2 layer, the metal segment **115c** of the M1 layer, the via **207c**, the CA contact **205d**, and the metal segment **201e** of the M0 layer are interconnected. The via **207c** and the CA contact **205d** are misaligned, wherein the metal segment **201e** is connected to the CA contact **205d** and provides additional surface area (e.g., wider upper surface at CA contact **205d**) for connecting with the via **207c**. In another contact point **209b**, the M0 metal segment **201d** is connected to the CB contact **205d**, which is connected to a PC **105**. The metal segment **201d** also provides a complete landing pad for the via **207b**. In an SRAM device, metal segments of the M2 layer (e.g. **211a** through **211c**) may be oriented perpendicular to the PCs **105**, wherein the M2 metal segments may provide connectivity to one or more power or signal sources. For example, the M2 metal segment **211a** may provide connectivity to a negative terminal (Vss) of a power supply, segment **211b** may provide connectivity to a bit select line, and segment **211c** may provide connectivity to a positive terminal (Vcc) of the power supply. In terms of layout, M0 does not need an enclosure rule around contacts CA and CB because it merely extends the CA and CB area. Therefore, M0 will not impose a rule that potentially increases chip area.

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In FIG. 2D, each instance of a contact point **209a** through **209n** is associated with a PV band that includes an inner edge **D1** and an outer edge **D2**. The PV bands may indicate a range of minimum and maximum dimensions of an object that is to be printed onto an IC substrate. Additionally, routing/placement of neighboring contact points, for example, **209b** and **209c**, may be based on a threshold distance **215** between the neighboring contact points.

The embodiments of the present disclosure can achieve several technical effects, including improved connections between vias and contacts without increasing chip area by utilizing metal segments of an additional metal layer as landing pads for vias and also as local interconnects between contacts in an IC device. Further, the embodiments enjoy utility in various industrial applications as, for example, microprocessors, smart phones, mobile phones, cellular handsets, set-top boxes, DVD recorders and players, automotive navigation, printers and peripherals, networking and telecom equipment, gaming systems, digital cameras, or other devices utilizing logic or high-voltage technology nodes. The present disclosure therefore enjoys industrial applicability in any of various types of highly integrated semiconductor devices, including devices that use SRAM memory cells (e.g., liquid crystal display (LCD) drivers, synchronous random access memories (SRAM), digital processors, etc.), particularly for 7 nm technology node devices and beyond.

In the preceding description, the present disclosure is described with reference to specifically exemplary embodiments thereof. It will, however, be evident that various modifications and changes may be made thereto without departing from the broader spirit and scope of the present disclosure, as set forth in the claims. The specification and drawings are, accordingly, to be regarded as illustrative and not as restrictive. It is understood that the present disclosure is capable of using various other combinations and embodiments and is capable of any changes or modifications within the scope of the inventive concept as expressed herein.

What is claimed is:

1. A method comprising:

forming source/drain and gate contacts connected to transistors on a substrate in an integrated circuit device, each contact having an upper surface with a first area; forming metal segments in a plane at the upper surface of the contacts, each metal segment being in contact with one or more of the contacts and having a second area greater than the first area; and

forming one or more vias between one or more of the metal segments and one or more first segments of a first metal layer.

2. The method according to claim **1**, further comprising: forming one or more local connections between one or more of the metal segments and one or more of the source/drain and gate contacts.

3. The method according to claim **1**, further comprising: forming second segments of a second metal layer perpendicular to the gate contact and the one or more first segments of the first metal layer.

4. The method according to claim **3**, further comprising: forming vias connecting one or more of the metal segments or one or more of the first segments of the first metal layer to the second metal layer.

5. The method according to claim **3**, further comprising: forming first and second interlayer dielectric (ILD) layers; forming the vias through the ILD layers; and

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forming the metal segments and the first metal layer in the first ILD layer, and the second metal layer in the second ILD layer.

6. The method according to claim **3**, further comprising: connecting one or more of the second segments of the second metal layer to a power layer, a ground layer, and a bit line.

7. The method according to claim **1**, further comprising: forming the metal segments based on process variation (PV) bands including an inner edge and an outer edge.

8. The method according to claim **7**, wherein the PV bands of adjacent metal segments are separated by a threshold distance.

9. A device comprising:

source/drain and gate contacts connected to transistors on a substrate in an integrated circuit device, each contact having an upper surface with a first area;

metal segments in a plane at the upper surface of the contacts, each metal segment being in contact with one or more of the contacts and having a second area greater than the first area; and

one or more vias between one or more of the metal segments and one or more first segments of a first metal layer.

10. The device according to claim **9**, wherein one or more of the metal segments form one or more local interconnects with one or more of the source/drain and gate contacts.

11. The device according to claim **9**, further comprising: second segments of a second metal layer perpendicular to the gate contact and the one or more first segments of the first metal layer.

12. The device according to claim **11**, further comprising: vias connecting one or more of the metal segments or one or more of the first segments of the first metal layer to the second metal layer.

13. The device according to claim **11**, further comprising: first and second interlayer dielectric (ILD) layers, wherein the vias are through the ILD layers, and wherein the metal segments and the first metal layer are in the first ILD layer, and the second metal layer is in the second ILD layer.

14. The device according to claim **11**, wherein one or more of the second segments of the second segments of the second metal layer are connected to a power layer, a ground layer, and a bit line.

15. The device according to claim **9**, wherein the metal segments are based on process variation (PV) bands that include an inner edge and an outer edge.

16. The device according to claim **15**, wherein the PV bands of adjacent metal segments are separated by a threshold distance.

17. A method comprising:

forming source/drain and gate contacts connected to transistors on a substrate in an integrated circuit device, each contact having an upper surface with a first area; forming metal segments in a plane at the upper surface of the contacts, each metal segment being in contact with one or more of the contacts and having a second area greater than the first area;

forming one or more vias between one or more of the metal segments and one or more first segments of a first metal layer;

forming one or more local connections between one or more of the metal segments and one or more of the source/drain and gate contacts;

forming second segments of a second metal layer perpendicular to the gate contact and the one or more first segments of the first metal layer; and
connecting one or more of the second segments of the second metal layer to a power layer, a ground layer, and a bit line. 5

18. The method according to claim **17**, further comprising:

forming vias connecting one or more of the metal segments or one or more of the first segments of the first metal layer to the second metal layer. 10

19. The method according to claim **17**, further comprising:

forming first and second interlayer dielectric (ILD) layers;
forming the vias through the ILD layers; and 15
forming the metal segments and the first metal layer in the first ILD layer, and the second metal layer in the second ILD layer.

20. The method according to claim **17**, further comprising: 20

forming the metal segments based on process variation (PV) bands including an inner edge and an outer edge, wherein the PV bands of adjacent metal segments are separated by a threshold distance.

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